

ent in large quantity. Journ. Franklin Inst., xxv, 1840, pp. 158-162; Sturgeon. Ann. Elec., v, 1840, pp. 203-208.

BY DR. H. R. LINDERMAN AND PROF. ROBERT E. ROGERS

Report upon the Wastage of Silver Bullion in the Melter and Refiner's Department of the Mint of the United States, July 25, 1872. 8vo, pp. 82. Government Printing Office, Washington, 1872.

Report of the Committee [Franklin Institute] on Dynamo-Electric Machines. Journ. Franklin Institute, lxxv, 1875, p. 289-303.

Report of the Committee [Franklin Institute] on the precautions to be taken to obviate the dangers of Electric Lighting. Journ. Franklin Institute, Dec., 1881. lxxxii, pp. 401-408.

NOTE.—In the preparation of the above lists, the Catalogue of Scientific Papers, 1800-1873, compiled and published by the Royal Society of London, has been consulted and used.

Report on the Coal Deposits near Zacualtipan, in the State of Hidalgo, Mexico. By E. D. Cope.

(*Read before the American Philosophical Society, Oct. 16, 1885.*)

Having obtained in the City of Mexico favorable information as to the coal of Zacualtipan, in the State of Hidalgo, I resolved to devote some time to an investigation of that locality.

On my arrival at Zacualtipan, I was informed by my friend, Dr. Santiago Bernad, a French physician, who practices in the town and its surrounding region, that the coal beds extend throughout a distance of five leagues north and south, and two and a half leagues east and west. They are owned in large tracts called quadras by different persons. I examined sixteen exposures within a distance of five miles of Zacualtipan, north-east, south-east and south, with the following results:

The geological structure of the country is as follows: The town of Zacualtipan is situated on the border of the plateau of Mexico, where it begins to break off to the lower level, which two days' journey on horseback eastward becomes the Tierra Caliente of the State of Vera Cruz. The plateau is, therefore, much broken by ravines which open to the eastward. The high plateau just east of Zacualtipan is about 7000 feet above sea-level. The eastern border of the plateau is supported and protected by the lines of several trap-dykes, whose faces form precipitous walls which bound the ravines, generally on one side. To the east and west of the town the high lands consist of a silicious limestone, which looks a good deal like that of subcarboniferous age in the United States, but, is said by M. Barcena, of the National Museum of Mexico, to be of Cre-

taceous age. This limestone lies elevated at a high angle against the trap-dyke, at a point on the San Miguel creek; showing, first, that the trap formation is a dyke which has been thrust up from below, and is not an outflow; and second, that the age of the elevation of the dyke is later than the Cretaceous period. This conclusion is all important in the determination of the age, and, therefore, probable quality of the coal, and in the determination of its quantity.

The coal formation lies horizontally bedded in the intervals between the trap-dykes and the hills of limestone, etc. It consists of regularly stratified beds of clay, of volcanic ash, of clay or carbonaceous shales, more or less finely bedded, and of thicker and thinner beds of a frequently very good lignite coal. There are no beds of stone in them, but the carbonaceous shales are frequently very tough. The bedding has not been affected by the dykes, and indeed sometimes inclines downwards towards them at a low angle, instead of upwards towards them as would have been the case had they been older than the dykes. Further evidence that the coal formation is newer or of later age than the dykes is seen in the fact that beds of coal are found in some localities on top of them. It follows from these facts that although there are beds above the dykes, there *is no coal* below the precipices which constitute the parts of the dykes which are visible; or, in other words, that the coal only occupies the spaces between the dykes. Fossil mammalian remains found in the beds of clay near the coal prove that the formation is of Upper Miocene Tertiary age, and perhaps identical with the epoch known in North America as that of the Loup Fork.*

The properties which I examined bear the following names: Galiana, Hulla, Juarez, Concha, Providencia, Capa Rosa, Sausz, San Miguel and San Rafael. I take them up in order. I premise by saying, that the coal beds have been rendered accessible by the erosion of the middle parts of the valleys which they occupy, into deep ravines. The coal outcrops are on the sides of these ravines, and extend underground to a line which descends vertically continuous with the faces of the trap precipices, at which point they are cut off by the concealed part of the dyke. The amount of coal is of course to be determined from this dimension, *i. e.*, the distance from the dyke multiplied by the extent of the formation parallel to the dyke, by the thickness of the bed.

The coal beds are best exposed on the Galiana property. From the top of the trap dyke to the bottom of the valley at this point, the vertical depth is about one thousand feet. At a depth of about 100 feet from the summit of the hill is a short, open cut in which can be seen a bed of good coal of eighteen inches in thickness. From its position, this bed probably extends entirely across the summit of the hill, and crops out on the other side, forming the San Rafael mine. Below this open cut the summit of the trap precipice is soon

* See American Naturalist, May, 1885, where this fact is stated. See also description of fossils at end of this article.

reached. The foot of the precipice is perhaps 400 feet below the coal bed, and at its foot is a gently sloping plateau of perhaps a quarter of a mile in width. The slope then becomes more abrupt, and descends to the bottom of the ravine-like valley, 500 feet below. At a depth of fifty feet vertically below the foot of the precipice at the beginning of the steeper slope, the upper bed of this part of the Galiana crops out. It is one foot in thickness, and is of good quality. Some eighteen inches of clay intervene between it and a second bed of coal of about three feet in thickness. About forty feet below their level is a bed of impure lignite eighteen inches thick; and below three or four feet of clay is a bed of better lignite which varies from two to six inches in thickness. Below this are about eighteen feet of carbonaceous clay and shale, and below this fifteen feet of clay with thin seams of lignite. Below this succeed white slates and clay with vertebrate fossils, chiefly three-toed horses, but no more coal.

The workable beds of coal in this property are the eighteen inch bed above the precipice, and the eighteen and thirty-six inch beds below the precipice. At present these beds are only exposed in open cuts. Those below the precipice have a quarter mile (English) extent to the trap dyke, while their extent parallel to the dyke is probably considerable. In fact, the coal formation follows the borders of the dykes at varying distance, and the outcrop thus has many miles of extent. The workings on the Galiana property consist of nothing but the open cuts mentioned. The clay is of excellent quality, and is manufactured by the owner into roofing tile.

The Hulla and Juarez mines are on the other sides of the same trap plateau. The highest coal outcrop of the Hulla is above the dyke precipice on the opposite side from the highest exposure on the Galiana, and is probably the same bed. This will therefore be about a third of a mile between the two outcrops. The bed is, however, thinner on the Hulla side, being only six inches in depth. The same is true of the other outcrops on the Hulla side. The second one is perhaps 500 feet lower down towards the bottom of the valley. There are open cuts, but the principal exposure is clay, carbonaceous and otherwise, with a bed of pure lignite of six inches thickness. At the Juarez outcrop, several hundred feet lower down, the lignite bed is only an inch in thickness.

The Concha and Providencia mines lie south-east of Zacualtipan, and below the trap precipice already described. They are, however, near to another mass of trap which may be a part of a different, or a branch of the same great dyke. The Concha is developed by both an open cut and a timbered drift. The bed of coal varies from thirty to eighteen inches in thickness, and lies between more or less shaly beds of clay. They all dip at a low angle towards the trap. This coal looks well, but the extent of the bed *in one direction* is probably reduced by the not far-distant dyke. Lower down the hill we sought for another outcrop on the Concha property, but it had been covered up. An eighth of a mile round the hill from this lower level, in the side of a ravine is a cut, which displays the bed of

the Providencia mine. This varies in thickness from eighteen to thirty inches. In one direction it is limited by a trap dyke at a distance of about 100 yards, whose exposed face is less than 100 feet in height.

South of Zacualtipan are situated the Guadalupe, Capa Rosa, Sausz and San Miguel mines. At the Guadalupe are two timbered drifts, whose length I did not explore, as they contained much water, and were more or less dangerous. The cuts at their mouths in the hillsides reveal their structure and general value. The rock consists of clay and clay shales more or less carbonaceous, not hard, but tough. The lignite proper is from six to ten inches in thickness. This cut is near the base of the trap precipice. The second cut is 150 feet off, and is that much further from the trap. It displayed much the same structure and quantity of lignite.

The Capa Rosa exposure is on another side of the same hill, and is a quarter of a mile from the precipice, thus giving promise of greater dimensions of the deposit in one direction. It is at nearly the same horizon as the Guadalupe, and may be the same bed. It is developed by an open cut which shows as follows: Below fifteen feet of soil there are twelve feet of clays and slates. These alternate between more and less carbonaceous layers, and in the bottom there are in sight ten inches of lignite, and how much more I could not ascertain without excavations. Further down the same hill, about 100 feet vertical, is the Sausz mine. The beds are here exposed by an open cut and a drift; the latter in a ruinous condition. In the bottom of the openings is a foot of good looking lignite, and above it is a bed of clay three feet in depth; above that, six inches of carbonaceous clay slate.

A mile farther along the same valley is the San Miguel mine. Its bed is exhibited in one open cut, and in an exposure along the bank of the San Miguel creek at the water level. There are here eight inches of lignite like that of the Capa Rosa and the Sausz.

It is now easy to perceive that the aggregate quantity of coal in the country is large, but that it is spread over considerable space. It is also evident that the mining is easy, as the beds all crop out conveniently on the sides of valleys, and the drainage is also easy. There being no secure roof or hanging wall to the beds, all workings will have to be well timbered. This will not be expensive, as timber of excellent quality of oak, pine, etc., covers the hills everywhere, in close proximity to the coal openings. The localities which exhibit the greatest thickness of the beds are the Galiana and Concha properties. Those which promise the greatest horizontal extent of the bed in the direction of the dyke are the Galiana, the Capa Rosa, the Sausz and the San Miguel. The property which combines the two advantages is then the Galiana.

This region is accessible by rail as far as Pachuca, sixty miles distant. From Pachuca to Zacualtipan a railroad could be built by Tulancingo and Apulco, where is now a wagon road. Of this I am informed by various persons, among them by Professor Castillo of the School of Mines of Mexico. A direct line of road from Pachuca to Zacualtipan is impracticable or

very expensive, owing to the great inequalities of the country. It is not unlikely that at some future day, this coal will have an outlet to Tuxpan on the coast, which is due east from Zacualtipan.

Finally I refer to Dr. F. M. Endlich for information as to the quality of the coal and its availability for industrial purposes.

I add that several of the properties are in the state of Vera Cruz just over the line. The Galiana property is near the small village of Tehuichila, Vera Cruz.

Description of fossils.

HIPPOTHERIUM PENINSULATUM, sp. nov.

Crown of superior molar long, curved. Grinding face with anteroposterior diameter considerably exceeding the transverse. Internal column large, its section a narrow anteroposterior oval, with both borders convex. Internal enamel borders of internal crescents with a prominent loop at junction, the posterior one with its posterior loop much smaller than the column. A subquadrate area between the internal parts of the lakes, is connected by an enamel ridge with the anterior lake. Opposite and adjacent enamel borders of the lakes, with several close and deep plications, which nearly cut off the adjacent horns. In like manner the posterior horn of the posterior lake, and the anterior horn of the anterior lake are almost cut off by the deep complex infolding of the anterior and posterior borders respectively. The median and anterior external ribs of the crown are well developed, and there is but little cement on the grooves.

	<i>Measurements.</i>	M.
Length of root, less crown.....		.050
Diameters of grinding face {	anteroposterior.....	.018
	transverse.....	.015

This superior molar tooth indicates a small species of the genus, and one which is entirely typical in form. The plication of the enamel is greater than in any other species excepting the *H. gracile*. It resembles most of all the *H. venustum* of Leidy, which is of similar dimensions. In that species the style has a nearly circular section according to Leidy, which distinguishes it satisfactorily.

From the Loup Fork Shales of Tehuichila, Vera Cruz.

PROTOHIPPIUS CASTILLI, sp. nov.

This horse is represented by a superior molar tooth of a larger animal than the species last described, and one only a little smaller than the zebra. It possesses the internal loops of the two internal crescents as in *Hippidium* and *Protohippus*, and without the bones of the feet it is impossible to determine to which genus it should be referred. The indication that it is a *Hippidium*, is derived from the relative proportions of the internal loops. The anterior of these is much larger than the posterior, and occupies the median position of the internal edge of the crown like the column in *Hippotherium*. Further approach to that genus is made by the con-

traction of its connection with the corresponding crescent. The section of this loop is a rather wide oval. The posterior loop has half the size, and if isolated would present the same form.

The crown of the tooth is of median length and is strongly curved inwards. Its grinding surface is a little wider than long, and is worn into two transverse angles, which pass through the concavities of the borders of the crown and lakes. It is not certain that this grooving in wear is a constant character.

The lakes are strongly convex inwards and their horns are wide and obtuse. Their borders are simple, there being no folds on the remote sides, and on the adjacent borders only one on the posterior and two on the anterior, of no great depth. There is no loop at the junction of the inner edges of the internal crescents. External ribs of crown prominent. Excepting these, the entire crown is enclosed in cementum.

	<i>Measurements.</i>	M.
Length of crown.....		.040
Diameters of grinding face {	anteroposterior021
	transverse.....	.023

This species differs from the *P. insignis*, *P. perditus* and *P. mirabilis*, with which it agrees in size, in the posterior production and angulation of the posterior border of the anterior inner column, and in the absence of plication of the borders of the lakes which are remote from each other. In this species the internal loops are of nearly equal size. I have dedicated it to my distinguished friend, Prof. Antonio de Castillo, Director of the School of Mines of the City of Mexico, to whom I am indebted for a knowledge of the locality described in the present paper.



Fig. 1.

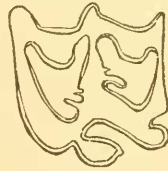


Fig. 2.

Fig. 1. Superior molar tooth of right side of *Hippotherium peninsulae* Cope grinding surface from below; natural size.

Fig. 2. The same of *Protohippus castilli* Cope; same view; natural size.